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Multipliers, markups, and mobility rents: in defense of 'chain models' in urban and regional analysis

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Abstract. Social scientists have long used 'chain' metaphors, yet their methodological justification remains somewhat hazy. This paper offers a rationale for using chains to measure changes in economic welfare in urban and regional contexts. In contrast to the Marshallian surplus, which well describes situations in which price changes generate rents in a single market, chains are especially useful in markets where changes lead to the transmission of demand or supply through a series of markets characterized by sticky prices and markups. This argument is illustrated by reference to chain-driven analyses of local production, labor, and housing markets. The institutional structures that underpin chain models are stressed.

Introduction

Social scientists have long used 'chain' metaphors to conceptualize the operation of key parts of the economy. The workings of the housing, labor, and production markets have all been explained as subject to predictable linear processes whereby a change in one part of a given system elicits responses in other parts of the system. Recently, we have presented an approach to labor chain modeling for use in evaluating welfare gains from economic development activities at the local level (Persky et al, 2004). This model draws on a tradition of 'chain analysis' built by sociologists, economic geographers, and regional scientists. This modeling strategy has been common in the study of housing vacancies. Demographers have used chains extensively for the study of migration patterns. Perhaps economists and regional scientists are most familiar with chains in the context of Leontief input – output tables and the related tools of impact analysis. While chains are common in social science research, their methodological justification remains somewhat hazy. The purpose of this paper is to provide rationales for when to choose and when not to choose chain approaches in urban and regional research.

Researchers' treatment of chains can often appear mechanistic and thus further strengthen suspicions that these tools lack strong theoretical underpinnings. Chain models hardly ever build on formal maximizing behavior by individuals or firms, pay little attention to short-run price changes as an allocation method, and often ignore issues of market clearing. Obviously, for problems where these elements are of prime importance, chains are not going to do a very good job for either description or prescription.

Despite these issues, we maintain that chains do have a place. More than thirty years ago, White (1970; 1971) argued that chain models offered promise for describing elements of markets as diverse as those for housing, labor, and secondhand cars. He emphasized the common theme of mobility in these fields and began a critique of traditional market approaches to such phenomena (White, 1970, chapters 8 and 13) considering some eighteen model characteristics over a dozen alternative models of mobility.

White's survey is a rich source of material that has been less than fully exploited in urban and regional analysis. Here, we certainly do not claim to replace or even summarize that broad survey. Rather, we focus on one contrast, that between models which rely heavily on the traditional Marshallian surpluses and those which emphasize the transformation or transition of inputs. While White notes this contrast, he discusses it only briefly in his work.

The Marshallian cross provides a strong theoretical paradigm for situations in which changes generate rents for either buyers or sellers in a particular market (Marshall, 1961). Chains, however, stretch across and connect markets. We suggest a basic theoretical rationale for using chain methodologies in urban, regional, and planning research: *the description and welfare analysis (including distributional analysis) of changes which generate rents over a series of markets related through predictable institutional pathways.* In this approach, chain analyses are examples of general equilibrium models. However, unlike the abstract economic approach to general equilibrium, chain models emphasize structural/institutional lines of transmission. These lines of transmission work not so much through price changes as through predictable cascades in demand or supply.

In advancing this proposition, we review the major applications of chain analysis with an eye to their successes and failures. We argue that the best applications have occurred precisely when exogenous changes led to transmission of demand or supply through a series of markets characterized by sticky prices and short-side power.(1) The worst stumbles in applying chain theory have emerged where price changes short-circuit the underlying logic of the chain approach. We illustrate chain-type applications in regional input–output, local labor market, and housing market analyses. These highlight the role of mobility rather than price movements as a source of local and regional change. We conclude with a synthesis of the three archetypal uses of chain models in urban and regional analyses and emphasize the need for chain users to provide more extensive motivation for the fixed character of their price systems and transition matrices.

Applications of the chain metaphor

At the heart of the 'chain model' is the observation that a move by an individual will predictably and relatively quickly affect other parts of the system. While White's (1970) seminal book is often credited with introducing the notion of chain reactions in diverse social systems, the roots of the idea can be traced to early descriptive studies in the housing market literature (Firestone, 1951; Kristof, 1965). These spawned the housing market filtering literature that collected case-study evidence from a variety of settings and tried to draw urban planning and policy conclusions as to efficient allocation of housing for the disadvantaged. Much of this literature was concerned with nonprobabilistic and data-intensive charting of real-world chains. Little attempt was made at simulating or inferring chain dynamics using probabilities. From the 1960s up to the present, this concern with filtering in housing markets has continued to sporadically occupy urban geographers and sociologists. As housing units are well-defined entities that can be identified and contacted, much of this work has taken the form of place-based studies that trace vacancies through the direct surveying of households and make inferences about average chain lengths (Adams, 1973; Dzus and Romsa, 1977; Forrest and Murie, 1994; Lansing et al, 1969; Millard-Ball, 2002; Watson, 1974).

(1) Of course, sticky prices may arise from a number of institutional structures. We find most interesting the observation that short-side power may generate sticky prices. Short-side power emerges when markets are perennially in a condition of excess demand or excess supply. The concept of short-side power has been developed by Gintis (1989).

An alternative approach to chain analysis has taken the probabilistic route. Rather than directly mapping chains, convenient mathematical shorthand allows for the estimation of chain length based on the probability that a vacancy at a given level will be filled from a given origin state. In this approach, the properties of chains are simulated synthetically rather than identified empirically. While there are a number of variants on the probabilistic model, they all simulate the way in which new vacancies are diffused through a system. The key here is that the move of a vacancy (originating in a new home or job) from one class to another (as a household or worker moves in the opposite direction) can be assigned a probability of transition. If these probabilities are stable, the response of the system to any initial set of new vacancies can be simulated. A key property of these models is that vacancy moves are determined solely by current states. This makes the model particularly appropriate for simulating moves between units or vacancies such as cars, houses, or jobs. These are devoid of accumulated feelings or choices that could affect their present state. Furthermore, all models incorporate an absorbing state, which means all chains terminate at some point (a housing vacancy may go to a newly formed household, leaving no further vacancy, or a job vacancy may go to a new entrant to the labor force, leaving no opening).[2]

The probabilistic model has been used as the workhorse of chain-based analyses. Chain length and individual mobility within chains have been examined empirically using variants of the model in housing market analyses (Emmi and Magnusson, 1994; 1995; Hua, 1989; Marullo, 1985; Sands, 1977; White, 1971), studies of occupational mobility (Emmi, 1986; 1987) and residential segregation (Huff and Waldorf, 1988).

Aside from matching dwellings and house buyers, the chain model has been used in other diverse social science settings as an instrument for analyzing how supply and demand conditions are coordinated and how a constant process of realignment between the two takes effect. Thus, it has been utilized for matching college football coaches with teams (Smith and Abbot, 1983), clergy with parishes (White, 1970), musicians with orchestras (Abbot and Hrycak, 1990), and even hermit crabs with shells (Chase et al, 1988). Three major subject areas, however, stand out in their applications of the chain metaphor.

The first relates to *labor market analysis*. Ostensibly, studies of labor market dynamics provide some of the work closest in spirit to the chain model. To start with the much-cited work of Holt and David (1966), labor economists have used vacancies, job searching, and matching functions in order to understand the vacancy – unemployment relationship in imperfect markets. This early work also stressed the demand-side dynamics of the labor market rather than emphasizing supply-side characteristics. In this work, vacancies and unemployment are the stock variables, regulated by the flow variables such as new hires and recalls into the labor market, etc, and eventually the market reaches an equilibrium state.

Building on this approach, the job flows literature further develops the vacancy – unemployment model, showing how job quits are procyclical and how vacancy chains are created in tight labor markets. The existence of vacancy chains is also central to understanding the procyclical behavior of quits (Akerlof et al, 1988). Vacancy chains are shorter when unemployment is high as the probability of terminating the chain is high with so many job seekers available, who offer no job replacement. As opportunities expand, quits will increase and therefore quit behavior is procyclical.

Job flow studies of labor market dynamics stress that in imperfect labor markets flows are often an important source of adjustment (Blanchard and Diamond, 1992; Burgess, 1994; Schettkat, 1996a). Flows reflect high levels of mobility that are not

[2] For a more formal treatment of the model see Bartholomew (1973) and Kemeny and Snell (1960).

captured in measures of net change. This labor turnover or churning suggests that there are subsurface movements that are not captured by indices of net employment change. An obvious source of this discrepancy is the existence of job chains. For the case of Germany, it has been estimated that 50% of employment mobility in periods of tight labor markets is due to this movement along job chains (the churning effect) and that this figure drops to less than 10% in periods of slack labor markets (Schettkat, 1996b).

The second subject area relates to *organizational studies*. Sociologists and organizational scientists have used the vacancy chain model to study intraorganizational mobility (see Stewman, 1975a; 1986). The focus of these studies is on occupational advancement and the type of organizations that promote or hinder this. Thus, Stewman (1986) uses extensive development of Markov chains in order to show that the probability of advancement within organizations is higher at intermediate levels than at lower levels. Harrison (1988) shows on the basis of US data how the vacancy chain model can predict movement between different occupations nationally. Both these studies illustrate how the linear mobility model developed by White (1970) can be extended to organizational mobility applications.

One of the main uses of vacancy models in this literature has been to show remarkable similarities in the social organization of different mobility systems. Using vacancy chains to trace career paths, Stewman (1975b; 1986) has shown how similar career patterns develop in very different organizations. While much of this work is concerned with developing the mathematical and graphic frameworks for calculating the probability of advancement within the chain, the results show that these mobility probabilities are relatively stable and do not decrease as much as expected as the individual moves up the career ladder. In fact, mid-level career positions often have greater mobility possibilities than lower levels, suggesting segmentation in intraorganizational labor markets.

The third area of application is that of *local economic development*. In this field the use of the chain model remains somewhat pedestrian. The sporadic studies that have appeared are mainly concerned with surveying and charting of chains. Two early papers looking at vacancy chains in the context of local economic development efforts relate to job shifting resulting from a program of employment creation in Alberta, Canada (Webster, 1979), and a similar process resulting from expansion of coal mines in the Hunter Valley New South Wales, Australia (Garner et al, 1981). In both cases, extensive empirical charting leads no further than estimates of chain length.

More recently, the 'mapping and tracking' variant of the chain model has been revived to evaluate the impacts of urban development corporations in three United Kingdom cities (Robson et al, 1999) and to investigate filtering in the office and industrial property markets of northeast England (Greenhalgh et al, 2003). Again, nonprobabilistic (mapping) methods are employed in order to estimate chain length for commercial property vacancies and the role of the development corporations in encouraging economic regeneration in cities. These studies found particularly short local chains and use this finding to buttress the case for local targeting.

Chains in action

We now review three different applications of chain-type models in urban and regional analysis. In each case, nonprice mobility, changes in quantity, and the existence of markups are sufficient conditions to change the welfare of producers, workers, and house owners. All three cases illustrate the possibility of local economic change via alternative mechanisms to competitive price-taking. The key analytic device for observing this kind of change is the chain. The chain models developed in each instance are far from identical but together they suggest insights into the institutional structures and nonprice mechanisms underpinning local and regional economies.

Production chains and the limits of Marshallian welfare analysis

As the above brief survey suggests, social science researchers have used a variety of chain approaches. In doing so, they have avoided the traditional microeconomic emphasis on the interaction of supply and demand. They have chosen chains over Marshallian welfare analysis. Why do these research topics not fit well in a Marshallian methodology? To explore this question, consider a traditional microeconomic analysis of a market with a highly elastic supply curve. Supply determines price, and demand determines quantity. A small shift in demand brings forth additional supply with little or no change in price. In the traditional version of this story, suppliers gain no new rents from the additional sales. However, this interpretation seems to contradict the keen interest most suppliers show in new orders at more or less fixed prices.

A long-standing critique of the basic story argues that suppliers work on a markup of their average or marginal cost. The persistence of such markups can be rationalized in any number of ways. One plausible version sees each supplier as facing a firm-specific downward sloping demand curve, reflecting elements of local monopoly power derived from location, service relations, and limits on information. Despite these monopoly elements, suppliers are eager for new orders at existing prices. In this story of monopolistic competition, firms work with excess supply and make real rents on additional orders. In this way, rents follow orders.

But what is true for a set of firms in industry A experiencing an increase in demand is very likely true also for their suppliers. As A-firms expand orders of intermediate goods, firms in industry B, C, etc also find themselves selling more and taking in more rents. The expansion of demand has stimulated the supplying firms to make purchases in a broad range of intermediate goods producers. For most of these producers, additional sales are likely to produce additional profits at something like a fixed markup or rent. Thus, even though they continue to sell at an unchanged price, supplying firms can make real gains.

These are real welfare effects. Moreover, they may lead to similar expansions in other intermediate industries that in turn expand the ones in the first round. The traditional Marshallian analysis is not well suited to clarify the level or the distribution of welfare outcomes following on the initial exogenous increase in demand. A chain approach that explicitly specifies the likely series of purchases gives a much richer starting point.

In this context, in order to see what is happening we need to trace back from the demand change to the inputs feeding supply. The trails radiating back over these inputs and beyond generate information about the impacts of the immediate change in demand. For the most part, those impacts are simply proportional to quantity.

The standard tool for dealing with such production chains is the Leontief input–output table. This gives a vector of gross quantities as its output. The relation between gross quantities and net changes in final demand captures the multiplier quality of chains. A well-known identity in input–output analysis expresses those gross changes (a vector $\boldsymbol{Y}$) as a chain of rounds of required spending, stimulated by the net change (a vector $\boldsymbol{X}$):

$$\boldsymbol{Y} = \boldsymbol{X} + \mathbf{Q}\boldsymbol{X} + \mathbf{Q}^2\boldsymbol{X} + \mathbf{Q}^3\boldsymbol{X} + \ldots, \tag{1}$$

where $\mathbf{Q}$ is the requirements matrix.

Although gross outputs are often added up in this way, the value of the component activities to participants is not well expressed by this sum. Welfare gains—that is, rents derived from markups—are likely to be proportional to levels of activity within an industry, but markups will generally differ across industries. Thus a vector $\boldsymbol{W}^{\mathrm{T}}$ of welfare weights can be used to turn the vector of outputs into a scalar welfare measure (V) as in equation (2):

$$\mathrm{V} = \boldsymbol{W}^{\mathrm{T}}\mathrm{Y} = \mathrm{W}^{\mathrm{T}}\mathrm{X} + \mathrm{W}^{\mathrm{T}}\mathbf{Q}\boldsymbol{X} + \boldsymbol{W}^{\mathrm{T}}\mathbf{Q}^2\boldsymbol{X} + \boldsymbol{W}^{\mathrm{T}}\mathbf{Q}^3\boldsymbol{X} + \dots , \tag{2}$$

where $\boldsymbol{Y}$ is the gross outputs generated by final demand shift $\boldsymbol{X}$ subject to the requirements matrix $\mathbf{Q}$.

Obviously, this is not the place for a full reinterpretation of input–output analysis. Our point is to simply underscore two well-known observations about this tool. First, it tracks the spread of an exogenous stimulus—final demand. Second, it works best in a system of rigid or fixed prices. Let us consider each of these in turn. The material here is hardly novel, but it will help to focus our discussion of other types of chains. Indeed, the present paper can be viewed as an effort to extend the rationale for input–output analysis to other uses of the chain metaphor, as applicable.

The most common purpose of regional input–output analysis is to trace the spread of final demands through the region's industrial system. It starts from the proposition that demand moves through such a system in a predictable manner. The central issue is the ultimate distribution of demand across industries. The variety of the interactions among industries means that differing initial demands lead to differing distributions of intermediate demands.

A concern with the spatial spread and distribution of demand in the industrial system is not typical of traditional perfect-competition microeconomics. Material inputs of various types play little role in microeconomic theory, although in general equilibrium analysis they may be paid lip service. Traditional neoclassical theory is far more concerned with the interaction of supply and demand in determining prices and quantities in a single market. In the standard microeconomic context, a rise in demand for a particular good is primarily of interest in terms of own price effects. Indeed, a change in quantity sold without a price change is almost a nonevent in such a world. For the microeconomist, 'prices matter'. Indeed, it sometimes seems that prices are all that matter. In a world of efficient markets, utility functions can be written indirectly in terms of prices; similarly, with respect to profit functions. Quantities fall into the background of the story and they clearly play a secondary role to prices.

But regional and urban input–output studies are prime examples of quantity analysis. In the world of input–output, whether for planning purposes or to gauge who is likely to gain or lose from demand changes, quantities matter. In the planning context, where market mechanisms for generating substantial increases in supply may be awkward, the purpose is precisely to avoid large induced price changes by anticipating quantity needs. The assumption is that such needs can be met at more or less fixed prices if approached in a timely manner. More commonly, where the prime interest is welfare/profit gains and losses, the key starting point is that these are considerably more influenced by quantity changes than by price changes. In well-developed market settings, supplies for most produced goods (as opposed to natural resources or goods heavily dependent on such resources) are highly elastic. Hence, price changes are small and insignificant.

In a sense, input–output analysis buys its practical power to model spread by ignoring the greater complexity of general equilibrium price adjustments in favor of greater detail on the spread of demand. An input–output model can present far more industrial detail than a computable general equilibrium model with far less data and much more manageable computational complexity.

For a wide range of impact problems, quantity changes are the best guide to welfare changes. The common policy view of input–output analysis most often makes just this assumption. At the local or regional scale, we do not expect sharp price changes as the result of demand changes. Especially in regional input–output analysis, supply elasticities are likely to be quite high as resources can be imported relatively easily. Where prices are sticky, welfare changes for business owners come in the form of markups tied to quantities. The greater the number of intermediate products purchased in the area, the greater the profits of the firms producing those products. Similarly, if the focus is on local labor markets then the more workers hired directly and indirectly as the result of the opening of a new factory, the greater the surplus received by workers. Prices or wages change occasionally, but in this world changes in quantities generally matter more. As long as weighting factors are relatively constant over time, the chain approach seems quite appropriate.

Labor chains: employment, unemployment, and vacancies

Long-term supply and demand decisions in labor markets have occupied a central place in applied microeconomics. The labor supply adjustments of workers to changing wage spreads—between skilled and unskilled labor, men and women, rural and urban workplaces, and many more—are the very essence of labor economics, not to mention economic history, demographics, and public policy. Similarly, the study of employers' responses to changing supply conditions—the growth of the college educated, international immigration, the expansion of the female labor force, etc—has made real contributions to our understanding of the modern economy.

All of these applications take as their starting point a change in prices. For all of them, 'prices matter'. Supplies or demand curves shift and prices change. Prices in the market change and economic behavior responds. Information is transmitted through the price changes. Price adjustment and response is what neoclassical labor economics is all about.

There is, however, a long tradition in labor economics, deriving from institutionalist and Keynesian sources, that downplays, rather than emphasizes, the role of prices in the everyday allocation of labor. In this view, wages tend to be slow to move and labor markets fail to clear on a short-run basis. Involuntary unemployment at the low-skill end of the labor market is not the exception in this perspective, but rather the rule. Labor reserves buffer and grease market adjustments. When aggregate demand increases, welfare gains occur not through price adjustments, but through quantity adjustments as unemployed workers obtain employment or underemployed workers obtain more appropriate jobs. Again, such a position gains additional plausibility in a regional context where labor supplies, even skilled labor supplies, are likely to be quite elastic.

A simple linear treatment of the aggregate demand multiplier has long been the heart of the Keynesian textbook model. However, that basic multiplier analysis leaves undeveloped the distributional consequences predicted by the model. At best, a statement can be made about changes in total GDP or total employment. The logical way to develop Keynesian distributional analysis is to more completely model the labor market using the chains approach. The chain metaphor well captures the key institutionalist and Keynesian distributional claims in the labor market. Those claims have long emphasized the great dependence of low-skilled workers relative to skilled workers on the expansion of demand.

Table 1. A job chain matrix.

Origin	New wage group				
	1	2	3	4	5
Wage group 1 (%)	q_{11} = 41.1	0.0	0.0	0.0	0.0
Wage group 2 (%)	q_{21} = 25.0	q_{22} = 52.9	0.0	0.0	0.0
Wage group 3 (%)	q_{31} = 4.8	q_{32} = 22.1	q_{33} = 46.6	0.0	0.0
Wage group 4 (%)	q_{41} = 2.2	q_{42} = 1.5	q_{43} = 18.5	q_{44} = 47.3	0.0
Wage group 5 (%)	q_{51} = 0.0	q_{52} = 0.3	q_{53} = 2.4	q_{54} = 13.3	q_{55} = 34.5
Unemployed (%)	t_{11} = 2.9	t_{12} = 3.8	t_{13} = 9.7	t_{14} = 15.8	t_{15} = 24.7
Not in labor force (%)	t_{21} = 4.0	t_{22} = 3.8	t_{23} = 7.5	t_{24} = 13.5	t_{25} = 30.5
In-migrant (%)	t_{31} = 20.1	t_{32} = 15.6	t_{33} = 15.4	t_{34} = 10.0	t_{35} = 10.2
Column sum (%)	100	100	100	100	100

Chain models offer an explicit, empirical framework to formalize such claims. In our own work, we have emphasized the central role of involuntary unemployment/underemployment in motivating our adoption of a chain approach (Felsenstein and Persky, 1999). If we accept this framework, the empirical challenge is to estimate a transition matrix to use in the job chain model. Such a transition matrix should allow us to follow the likely results of an expansion in demand at any given wage level. The matrix in table 1 is drawn from our work using the Panel Study of Income Dynamics, 1987–93 and relates to pooled national data for job changes over this period (Persky et al, 2004). The resulting data can be interpreted as representing an 'average metropolitan area'. Table 1 shows the likely recruiting pattern to jobs in five different wage categories, from the highest in column 1, to the lowest in column 5. Each column shows the proportion of vacancies at that level taken by job changers characterized by the wages on their former job (rows 1–5). Of course, no vacancy generates an endless chain. Rather, real chains are ended by a terminating event. Thus, in the matrix we include the probability that a vacancy in a given column will end in the hiring of an unemployed worker (row 6), a worker not in the labor force (row 7), and a worker in-migrating to the area (row 8). These last three categories of job takers leave no corresponding vacancy for others to fill. Finally, it seems inappropriate to allow new vacancies to 'cause' downward mobility. Presumably, downward movers would have been worse off, not better off, in the absence of the vacancy they fill. Hence, all the entries above the diagonal have been set to zero and the remaining entries in each column rescaled to sum to one.

Of course, there is an arbitrary element in characterizing jobs only by their wage levels—a type of boundary effects problem. Ideally, job classes would group together all jobs with similar skill requirements, wages, working conditions, and security. Structural divisions such as those of dual labor market theory (Dickens and Lang, 1985; Doeringer and Piore, 1971) and the segmented labor market (Gittleman and Howell, 1995; Gordon et al, 1982) approach seem particularly relevant to constructing such groupings.[3] From that perspective, the transition matrix can be viewed as summarizing the customary mobility levels accepted by employers. Unfortunately, no longitudinal dataset currently contains information sufficient to construct a transition matrix at this level of richness. For the present then we have used this somewhat arbitrary breakdown.[4]

[3] We should also note that table 1 lacks subtlety in its failure to explicitly acknowledge the increasingly important segment of undocumented immigrant workers in the US (see Phillips and Massey, 1999).

[4] Other options would involve running a sensitivity analysis or using an explicitly spatial analysis in which the probability of a move is a function of place measured continuously.

Once estimated, a transition matrix can be used to trace the impact of new vacancies in the average metropolitan area. To start with, it is a relatively easy matter then to estimate the expected length of chains (see Persky et al, 2004). Given this type of chain matrix, a Leontief inversion of the square top portion of the matrix can be used to estimate the length of typical vacancy chains. More importantly, this matrix can also act as the basis of a distributional analysis if we simply keep track of the expected numbers of workers moving between various categories. If we assume wages remain rigid at each level, these transitions can be weighted by change in workers' earnings to provide an expected distribution of welfare gains by groups.

More generally, the welfare gain v per job created at level j can be estimated as

$$v_j = \sum_i m_{ij}(w_i)\left[\sum_k q_{ki}g_{ki} + t_{ui}(1-o_{ui}) + t_{ni}(1-o_{ni}) + t_{mi}(1-o_{mi})\right], \tag{3}$$

where m_{ij} is the Leontief multiplier derived from a job chain matrix like that in table 1, w_i is the wage for a job at level i, q_{ki} is the entry on the kth row and ith column of the job chain matrix, g_{ki} refers to the percentage wage gain in moving from job type k to job type i, and o stands for opportunity cost, with u, n, and m being subscripts representing unemployed, out of the labor force, and in-migrant.[5]

Equations like (3) allow the estimation of the efficiency benefits associated with job creation, defined here as the ratio of welfare gains to new wages. Depending on the magnitude and character of the stimulus, a chain analysis of this type can provide considerable information about the economic value of job creation. In doing so, it offers a consistent extension of the Keynesian story in a world of involuntary unemployment/underemployment, rigid wages, and institutionally determined recruiting patterns. In particular, the chain approach clarifies the ongoing competition between the unemployed and the underemployed for job vacancies. Moreover, the chain approach provides a straightforward method to obtain estimates of the distributional consequences of job creation—that is, the share of welfare gains to workers at the low end of the wage distribution. The constructive nature of chain analysis makes such disaggregation straightforward.

The chain approach to evaluating job creation gives robust welfare estimates as long as the basic institutional structures supporting a chain remain stable. At some point, of course, such structures may break down. For example, a large increase in labor demand might result in sizable changes in wages and a range of substitutions, events better discussed in Marshallian terms. Hopefully, empirical research on the stickiness of wages will eventually allow us to identify such breaking points.

Housing chains and residential filter down

Rapid urban growth in the United States in the early 20th century gave rise to housing markets in which demand tended to outrun supply. Early observers such as Hoyt (1939) emphasized the role of new construction in opening vacancy chains.[6] While the Great Depression undermined real-estate markets of all types, World War II again restored the short-side power of suppliers. At the end of the war, with US housing in particularly short supply, the appeal of vacancy-chain methodologies became strong. In the late 1940s newly built homes set off very real chains of vacancies as families sought

[5] Perhaps the most difficult parameters to estimate in equation (3) are the opportunity costs (o_j) of the various terminal states in each column. In our own work, we try to link these opportunity costs to the expected unemployment rates for each type of worker.

[6] Grigsby (1963) presented a slightly different view. His concern with identifying housing submarkets led to the cross-classification of housing types with household types. This introduced a behavioral element into the mechanistic process of filtering (see also Galster, 1996).

housing opportunities. A short chain might mean a new dwelling was occupied by an in-mover to a region or a newly formed household. A long chain might retell the moves of a number of households each improving its housing quality. The end of such a chain might reach down to those of modest income and wealth, even though the start began in the upper regions of the income distribution.

Housing chains are easier to study than job chains or production chains. From the vantage point of practical data acquisition, housing chains have a great advantage. Researchers can reconstruct actual chains in a straightforward manner by simply tracing new home purchasers to their starting address and then determining the new household taking over that residence. Unlike jobs, structures have a clear identity independent of their inhabitants. Where it is often unclear who replaced whom in an actual job chain, for housing chains such determinations present only modest difficulty. Under the circumstances, actual chains can be estimated and statistics based on real observations rather than on probabilistic constructs as in the job case. Nevertheless, much housing chain work is conducted in the same probabilistic mode as job chains (Chase, 1991).

For example, table 2 presents a housing chain matrix based on the work of Emmi and Magnusson (1995). They look at housing chain vacancies in three Swedish cities over the period 1975 – 85 and define six housing sectors based on tenure, building type, and size. Like most of the housing literature, they view chains as the result of Markov vacancy moves. Thus, a transition event involves a vacancy moving from an origin state to a destination state. In table 2 we have recast these moves such that a transition event moves a household from an origin state to a destination state. The origin of a household is the destination of a vacancy and visa versa. The last three rows of table 2 refer to the 'absorbing state' probabilities—that is, households that offer no replacement for the housing vacancy that they occupy.(7) Given the formal similarity to our Leontief labor chains, we will refer to these as Leontief chains.

Such a matrix can then be used to calculate the expected length of housing chains, starting with each housing quality. Notice in this case the short side of the market is

Table 2. A housing chain probabilities matrix, Jonkoping, Sweden 1975 – 80 (source: calculated from Emmi and Magnusson (1995, table A.1.b, page 68).

Origin	Destination					
	1	2	3	4	5	6
1. Owner-occupied, single family	0.18	0.14	0.07	0.03	0.04	0.02
2. Owner-occupied, multifamily, large	0.06	0.07	0.02	0.01	0.01	0.00
3. Owner-occupied, multifamily, small	0.02	0.05	0.06	0.01	0.01	0.02
4. Rental, single family	0.05	0.04	0.05	0.05	0.03	0.02
5. Rental, multifamily, large	0.15	0.13	0.05	0.05	0.15	0.03
6. Rental, multifamily, small	0.10	0.15	0.19	0.07	0.16	0.17
In-migrants	0.17	0.19	0.18	0.09	0.17	0.18
New households	0.09	0.22	0.38	0.13	0.21	0.36
Housing loss	0.19	0.00	0.00	0.56	0.21	0.20
Total	1.00	1.00	1.00	1.00	1.00	1.00

(7) 'Housing loss' is an approximation of withdrawals from the housing stock due to demolition, etc. It is defined for each sector as the differences between new construction and change in the number of households over the period. Emmi and Magnusson (1995) note that these absorption probabilities are high (page 48). In more recent work on housing vacancy chains in Stokholm 2000 – 02, Magnusson (2006) has estimated lower probabilities for similar housing sectors, ranging from 0.22 to 0.41.

presumably the supply side, so that vacancies move spontaneously down a chain.[8] This matrix can then be used to calculate a vacancy multiplier for every type of newly constructed home.

While the housing literature lacks the formalized efficiency and distribution measures found in the labor literature, the analysis of distributional outcomes has had a primary place in housing chain studies. A key distributional proposition—that chains starting with high-quality new housing generate considerable welfare gains for modest income households—became the central claim of the filtering school of housing policy. As such, it was embedded into a range of public programs in the US and elsewhere. And, yet, over the years housing analysts have become largely disillusioned with the simple filtering story. In the process, the usefulness of housing vacancy chain modeling has also been called into question.

Empirical work on chains has raised severe doubts about the simple filtering story. Lansing et al (1969) found chains initiated by new construction often disrupted by immigration, new household formation, or demolition. As such, they generated few gains for low-income families. Similarly, Forrest and Murie (1994) found much churning, but little interclass filtering. On the basis of Swedish data, Magnussson (2006) shows that housing vacancies initiated in a suburb of Stockholm generate intrasuburban movement but do little for creating housing opportunities in the inner city. Even in the context of urban growth in developing countries, filtering is found to peter out before reaching the very poor (Ferchiou, 1982). Recent work by Skaburskis (2006) has even identified a 'reverse' filtering process in Canadian cities whereby prices of older housing units have risen faster than those of the newer ones. These gentrification-induced patterns work against any public policy measures to induce filtering and improve the welfare of low-income households.

In and of themselves, such observations do not demonstrate that chain modeling is inappropriate for housing studies. The fact that the chain does not go exactly where one hoped or expected is not a refutation of the approach. However, housing chain models have more serious problems than just their failure to give the hoped-for filtering result. While apartment markets show considerable price stickiness (Genesove, 2003), markets for owner-occupied housing tend to be volatile in terms of price. This volatility is in sharp contrast to the other markets discussed in this paper. With the supply side inelastic over the short and intermediate run, prices can vary considerably with demand changes. Substantial price changes lead to major welfare changes for various income and demographic groups. The distribution of welfare can be substantially effected by marginal changes. Rather than welfare effects being restricted to long well-defined quantity chains, they are likely to spread through price changes impacting large groups of owners and house hunters.

From the start, the housing filtering model was couched in terms of price adjustments as well as quantity changes. The analytical machinery necessary to follow such changes requires a full articulation of supply and demand elasticities through a range of quality levels.[9] Thus, changing local circumstances on the demand side are likely to produce very different results depending on broader market circumstances. Where we find a high degree of stability in labor chains over the business cycle (Persky et al, 2004), the cyclical nature of housing markets points toward considerable variation in the character of housing chains. This is because housing markets (and especially

[8] The usual assumption in the housing chain literature is one of excess demand and in the labor chain literature one of excess supply of labor. Emmi and Magnusson (1995) would call both of these Markov supply-of-vacancies models.

[9] See, for example, the essentially Marshallian treatment of filtering presented by McDonald (1997, pages 216–221).

their local variants) are essentially 'thin' markets (Nordvik, 2004). As such, not all housing opportunities are equally open to all subsectors in the market. These may vary over time (that is, at different stages in the business cycle) and over different locations. In the context of housing vacancies, Magnusson (2006) notes that the high level of segmentation in urban housing markets in Sweden effectively prevents chain-driven transfer of opportunities between housing groups. Forrest and Murie (1994) find sharply different housing chains in the booming southern English housing market of the 1980s and the same market in the recession of the early 1990s.

Such rapid changes in chain structures are matched by rapid changes in welfare consequences. The demographics of households involved in chains differ across the cycle. Hence, the direct and indirect welfare effects must differ. Moreover, changes in markets are spread to households not involved in the chain of transactions as housing price changes affect asset positions. With the capitalization of housing and its valorization as assets or investment goods, many units not directly involved in the chain process can be affected by market changes.

Housing chains computed at a given time and place can be used to construct multipliers and may provide useful institutional insights into the workings of the housing market. However, they cannot form a solid foundation for the type of welfare analysis identified in this paper. As such, they play a much more limited role than chain analyses in labor markets.

Conclusions

This paper has attempted to utilize the insights gained from input–output production chains in order to generalize to labor and housing chains. We note that multipliers, markups, and mobility rents characterize all three markets but to differing degrees. Table 3 summarizes the attributes of the three types of chains (production, labor, and housing) discussed above. All of these chains in principle allow the sequential recording of linked transactions. However, as seen in table 3, these chains appear quite different in several crucial respects. In particular, we see that housing chains embedded in active markets with considerable price variation present a set of attributes somewhat at odds with the other two market groups considered.

Table 3. Chains by attributes.

Attributes	G-chain (Leontieff—production)	L-chain (labor market)	H-chain (housing)
Direction of movement through chain	Goods—physical transformation (horizontal)	Workers—moving up Vacancies reaching down	Housing declining (if not renovated) Households improving in welfare
Driver of movement	Technology	Job opportunities	Housing opportunities
Stickiness in movement through chains	Low	High	Moderate
Role of prices	Fixed	Fixed	Variable
Welfare gains via	Quantity change	Job change	Quality change *and* asset prices
Characteristic of market	Highly elastic short-run supply	Highly elastic short-run supply	Inelastic supply in the short run

Much of this ‘uniqueness’ is attributable to the special nature of housing as a consumption good with inelastic supply over the short run. Housing is a heterogeneous, nontradable (spatially fixed) good, both highly durable over long time periods and yet physically modifiable. It has the attributes of both an asset good and an investment good, which means it can both be capitalized and require service (with the costs that this implies). For our purposes however, the salient point is that price changes in housing markets are more important than those in labor markets and play a more central role in allocating housing than labor.

When do chains provide more than a transactions accounting database? Or, put somewhat differently, when is a serial transactions accounting database the beginning of a model? From the above, we find that housing chains provide the least complete description of the markets in question. Because housing prices change and housing prices matter, welfare effects of transactions are not limited to participants in those transactions. While housing chains exist, they hardly tell the whole story. The institutional mechanisms are not as rigid; prices tend to clear markets, and allocation is strongly influenced by prices. Welfare effects also follow from price changes.

For labor chains and production multipliers, prices are much stickier. As a result, the major welfare consequences of transactions are largely limited to participants in those transactions. Institutional characteristics play a much larger role than active price adjustments in allocating scarce demand. While there may be modest roles for nonprice competition (quality of goods, delivery times, labor skills, etc), these are much more limited in their effects on nonparticipants than are more traditional price competition.

In the presence of well-working markets with active price competition, demand equals supply and market matching generates no meaningful chain. It is the combination of markup pricing and mobility-driven rents that makes chains interesting. Clearly, under these circumstances the significant research task is to more fully identify the institutional allocation mechanisms that lie behind the chains. For example, labor chains are influenced by nonprice factors such as personnel policies, union contracts, public referral services, and a range of other institutional structures.

Over time, most real-world markets evince aspects of broad price competition *and* narrower chain allocation. Recent research fashions have tended to emphasize the former, largely ignoring the institutional basis of the latter. Hopefully, a clearer statement of the usefulness of the chain approach can help to renew interest in the institutional allocation structures that characterize so much of the economy. Multipliers, markups, and mobility rents are often interconnected in ways best developed in a chain approach.

Input – output has been a basic tool of regional analysis and is well respected for its description of multiplier processes. It has long been recognized that input – output multipliers work best in an environment of fixed or sticky prices. Chain analogies may prove a poor choice for modeling housing markets, but labor markets, like input – output production systems, often evince just that combination of characteristics well described by chain mechanics. Labor chains add another dimension to the multiplier concept in a defensible context, one in which price changes play only a secondary role.

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